Armed Forces College of Medicine

AFCM

Ventilation Perfusion Ratio

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. List 3 differences between pulmonary & systemic circulation.

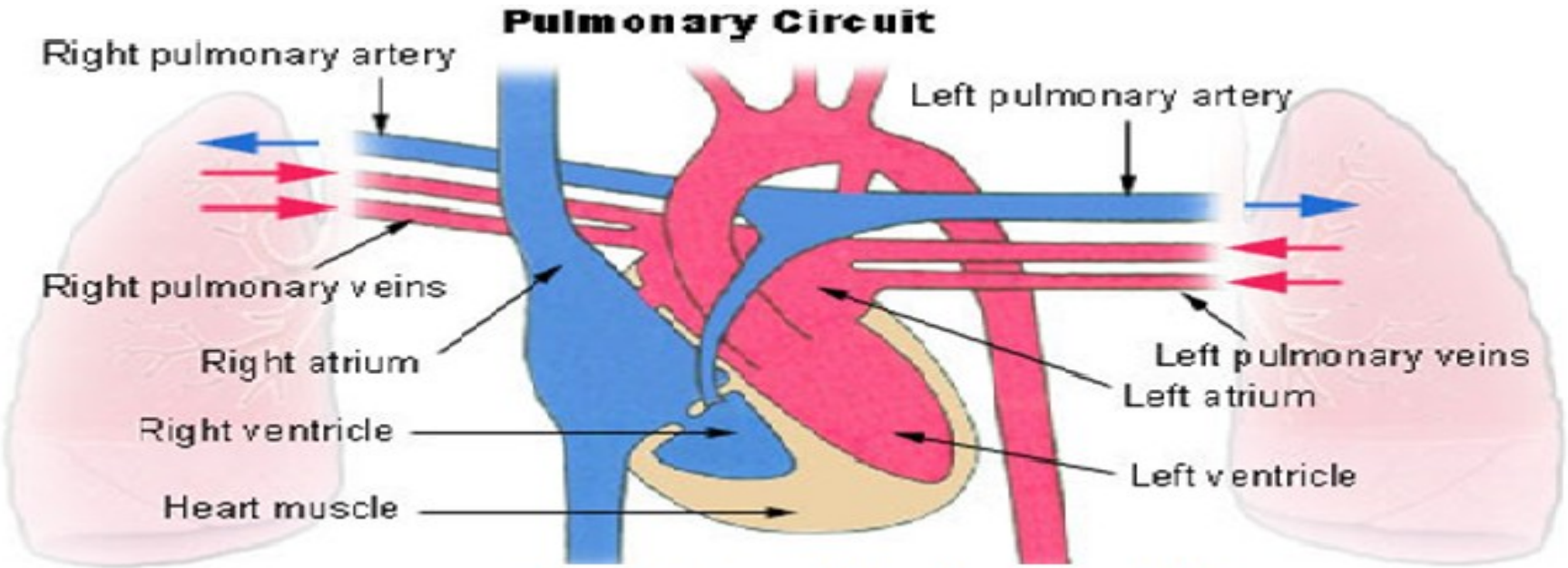
2. Explain the regional distribution of pulmonary blood flow.

3. Explain regional distribution in ventilation in the upright lung.

4. Define ventilation perfusion (V/Q) ratio &mention its importance.

5. Predict the consequence of high & low V/Q

Pulmonary Circulation



https://en.wikipedia.org/wiki

- It is the part of circulation that lies between the right ventricle and left atrium.
- The **pulmonary arteries** are the only arteries that carry *non-oxygenated blood* while the **pulmonary veins** are the only veins that carry *oxygenated blood*.

Characteristics of pulmonary :circulation

Low pressure & Low resistance system

Pulmonary arterial pressure 25/10 mmHg
Mean pressure 15 mm Hg

The pulmonary blood flow = the cardiac output which is about 5 liters

In **pulmonary** circulation
R= mean P/F
= 15/5= 3 mmHg/L/min

In **systemic** circulatio
R= mean P/F
= 90/5= 18
Hg/L/min

Characteristics of pulmonary :circulation

Pulmonary capillaries

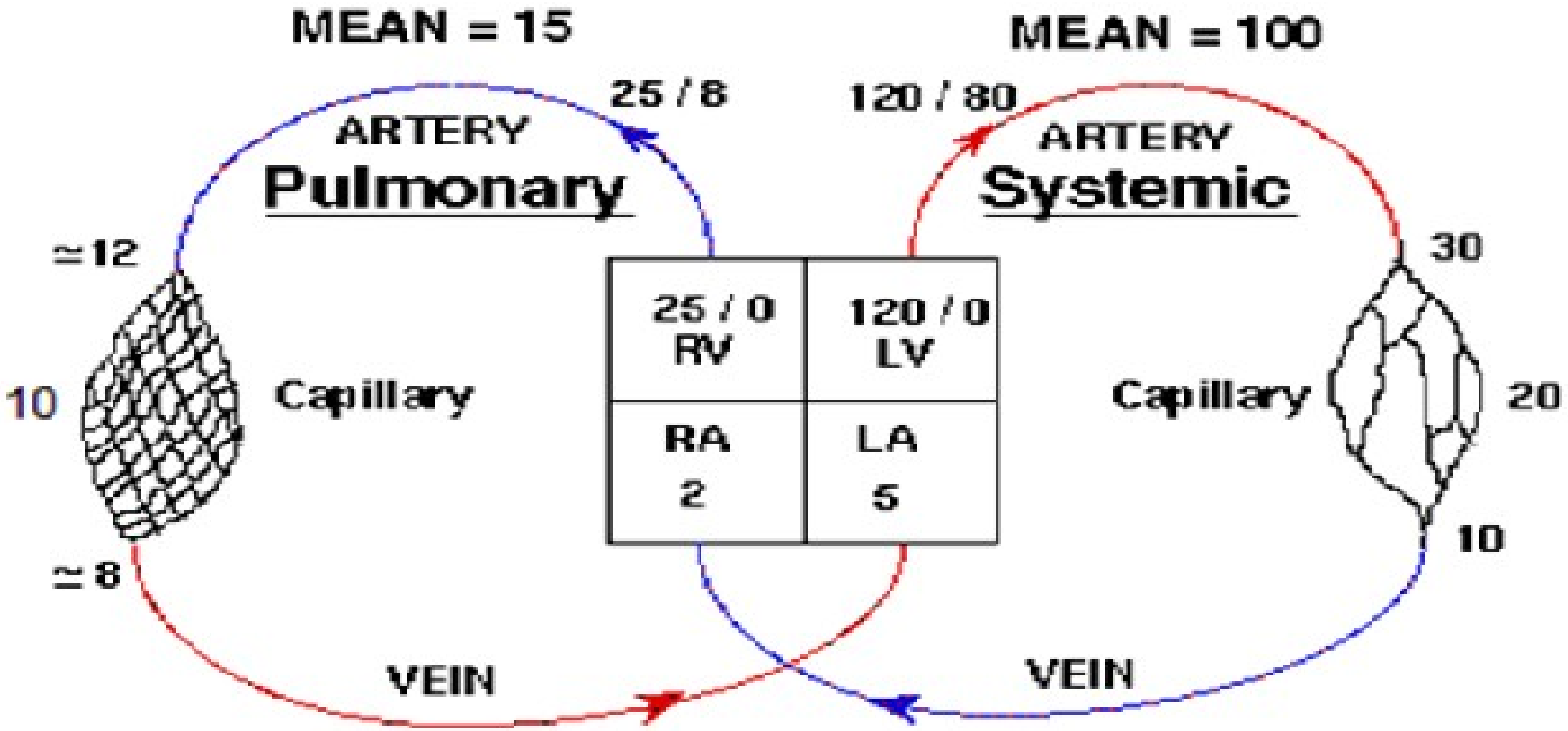
Large with multiple branches
Pulmonary capillary pressure
7-10 mmHg

Pulmonary arteriole

Little elastic &
smooth muscle fibe

The mean velocity of blood
is about 40cm/sec
& blood travels across pulmonary capillaries
in about 0.75 sec

Characteristics of pulmonary :circulation



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Characteristics of pulmonary :circulation

Effects of O_2 on pulmonary circulation are opposite t on systemic circulation

VESSELS	Effect of ↓ O_2	Effect of ↑ O_2
Pulmonary arterioles	Vasoconstriction	Vasodilatation
Systemic arterioles	Vasodilatation	Vasoconstriction

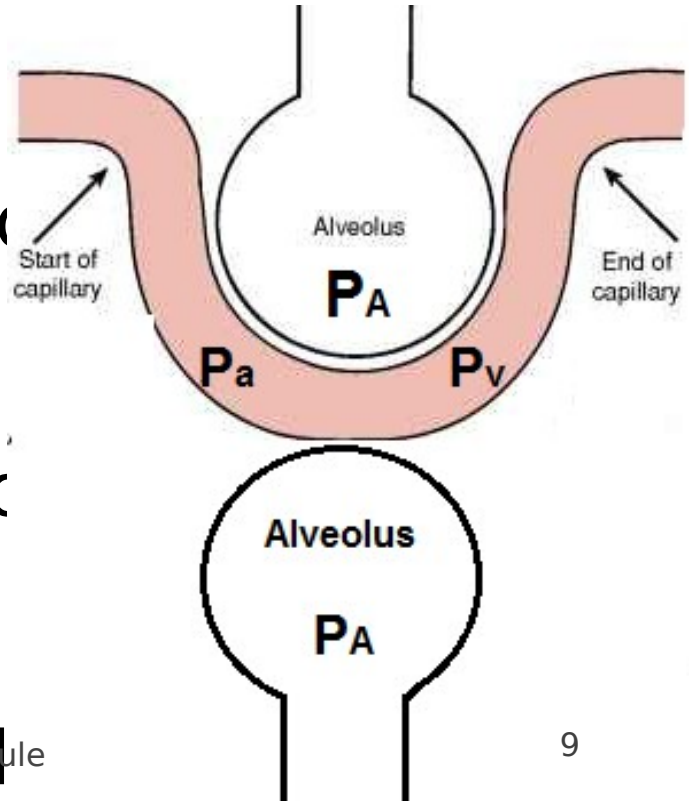
Generally, hypoxia in any organ causes vasodilatation to bring more blood with more O2 **EXCEPT** in pulmonary vessels where hypoxia causes vasoconstriction to shift blood to non hypoxic areas.

Characteristics of pulmonary :circulation

ct of gravity on pulmonary circula

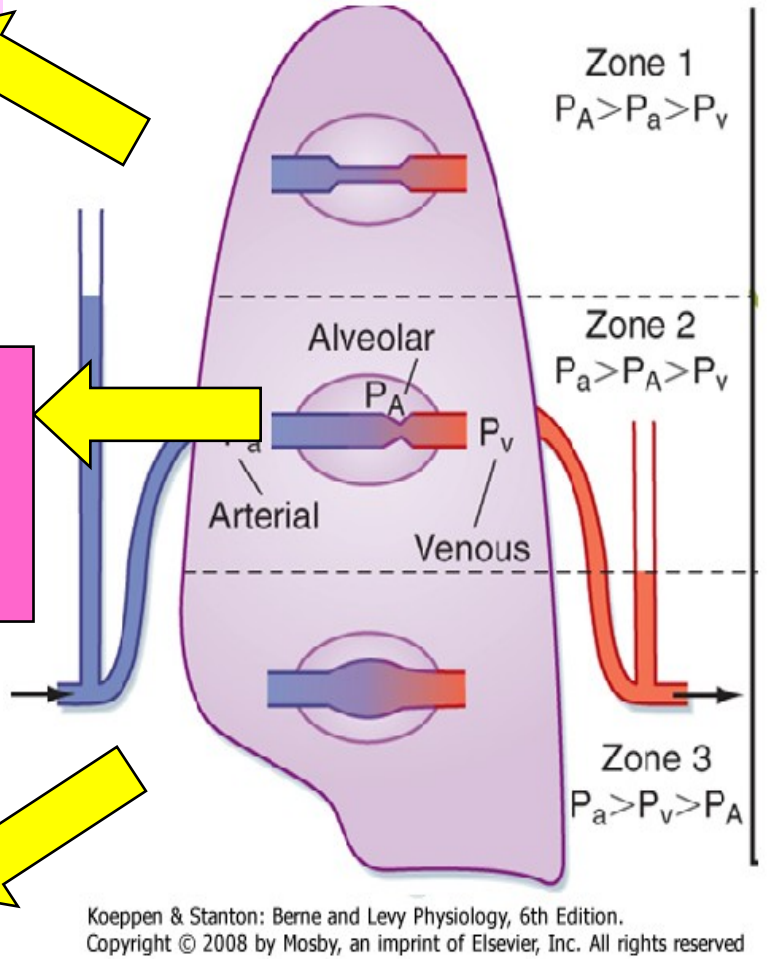
- **D**istribution of blood in lungs is affected by gravity

- The **apical** zone
  - very **minimal** bl
- The **intermediate** zone
  - **intermittent** bl
- The **basal** zone
  - **maximal** blood fl



The **apical** zone very **minimal** bl.flow as *(the pulmonary alveolar pr. > pulmonary arterial pr.)*

The **intermediate** zone **intermittent** bl. flow as *(the pulmonary arterial pr. > pulmonary alveolar pr.)*



The **basal** zone **maximal** bl.flow as *(the pulmonary arterial pr. > pulmonary alveolar pr.)*

Ventilation perfusion ratio (V/Q)

- **Def:**
  It is the ratio between the volume of alveolar ventilation (V) and the pulmonary blood flow (Q).

- **Normal values:**
- Alveolar ventilation = volume of air that enter in gas exchange per minute = **4.2** liters/min.
- Pulmonary blood flow = cardiac output = **5.5** liter

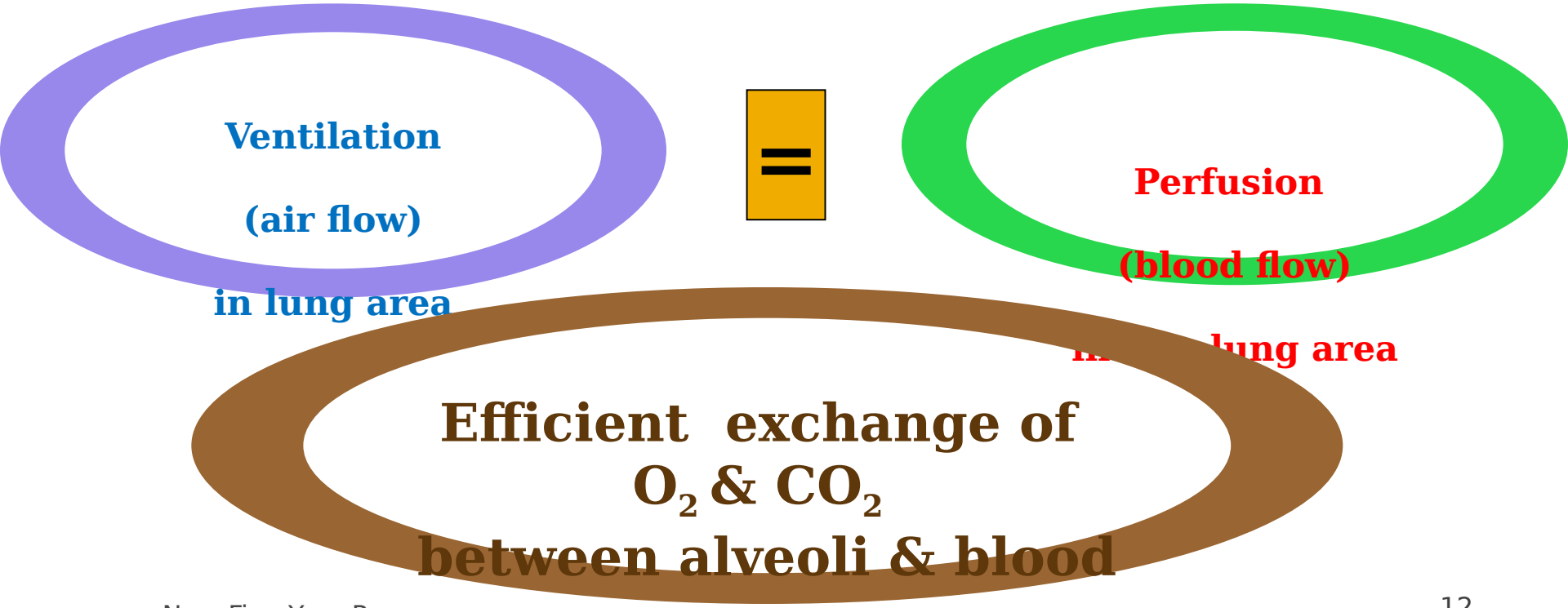
= **Alveolar ventilation / pulmonary blo**
= 4.2 / 5.5
= 0.8

- Both ventilation & perfusion are not equal throughout the lung so

Ventilation perfusion ratio (V/Q)

- **Importance:**

- Adequate gas exchange requires that ventilation & perfusion be matched to each other.
- So ,V/Q ratio is the main determinant of gas exchange across respiratory membrane.



Ventilation perfusion ratio (V/Q)

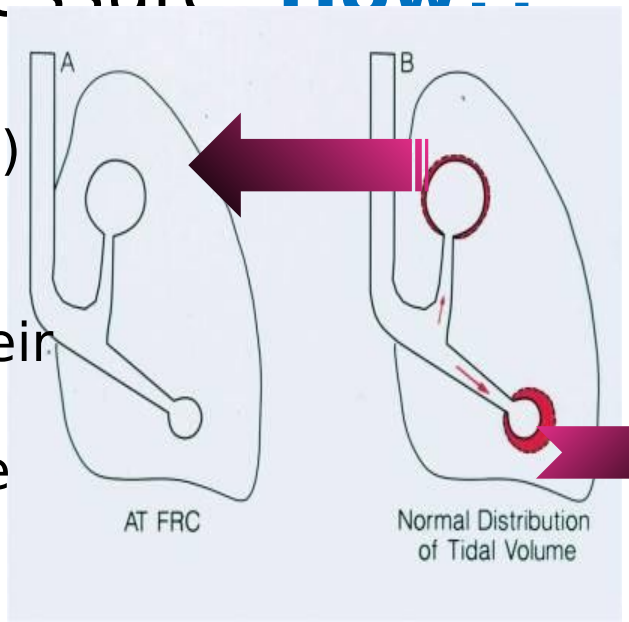
Regional distribution of ventilation:

- In the upright position, the alveoli at the **base** of the lung are ***better ventilated*** than those at the **apex** due to the effect of gravity on the intra-pleural pressure. **How??**

At the apex:

The IPP is more –ve (-10)

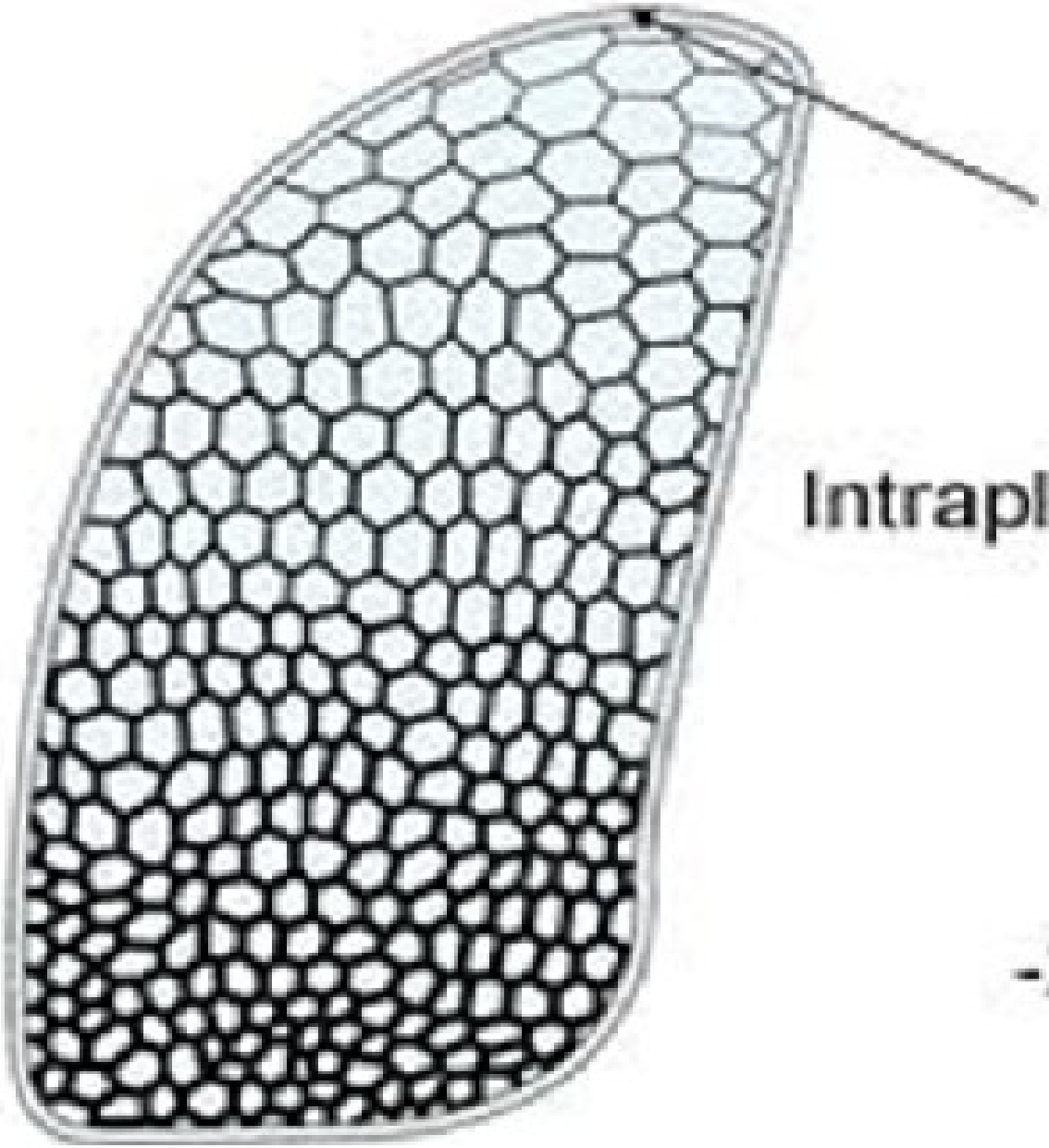
- greater TPP gradient
- apical alveoli are distended close to their full capacity with stretched, less mobile walls
- less compliance
- Less ventilated



At the base:

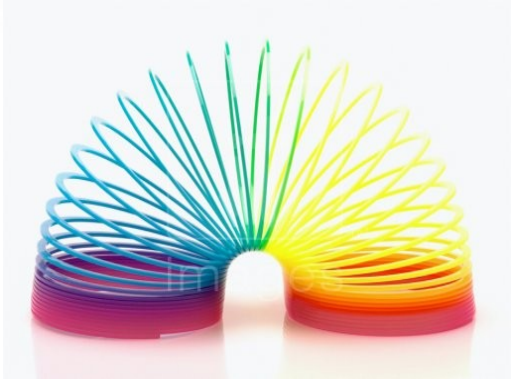
The IPP is less –ve (-2.5)

- less TPP gradient
- basal alveoli are less distended with smaller volume so can be inflated to a larger size
- more compliance
- better ventilated



-10 cm H_2O

Intrapleural pressure



-2.5 cm H_2O

Ventilation perfusion ratio (V/Q)

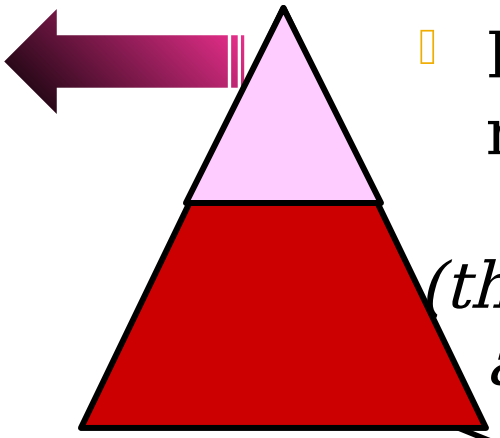
- ***Regional distribution of perfusion:***

- In the upright position, the alveoli at the **base** of the lung are ***better perfused*** than those at the **apex** . **How??**

- **At the apex:**

- Blood flow is minimal as

(the pulmonary alveolar pr. > pulmonary arterial pr.)



- **At the base**

- Blood flow is maximal as

(the pulmonary arterial pr. > pulmonary alveolar pr.)

Ventilation perfusion ratio (V/Q)

- **Both ventilation & perfusion ↓**

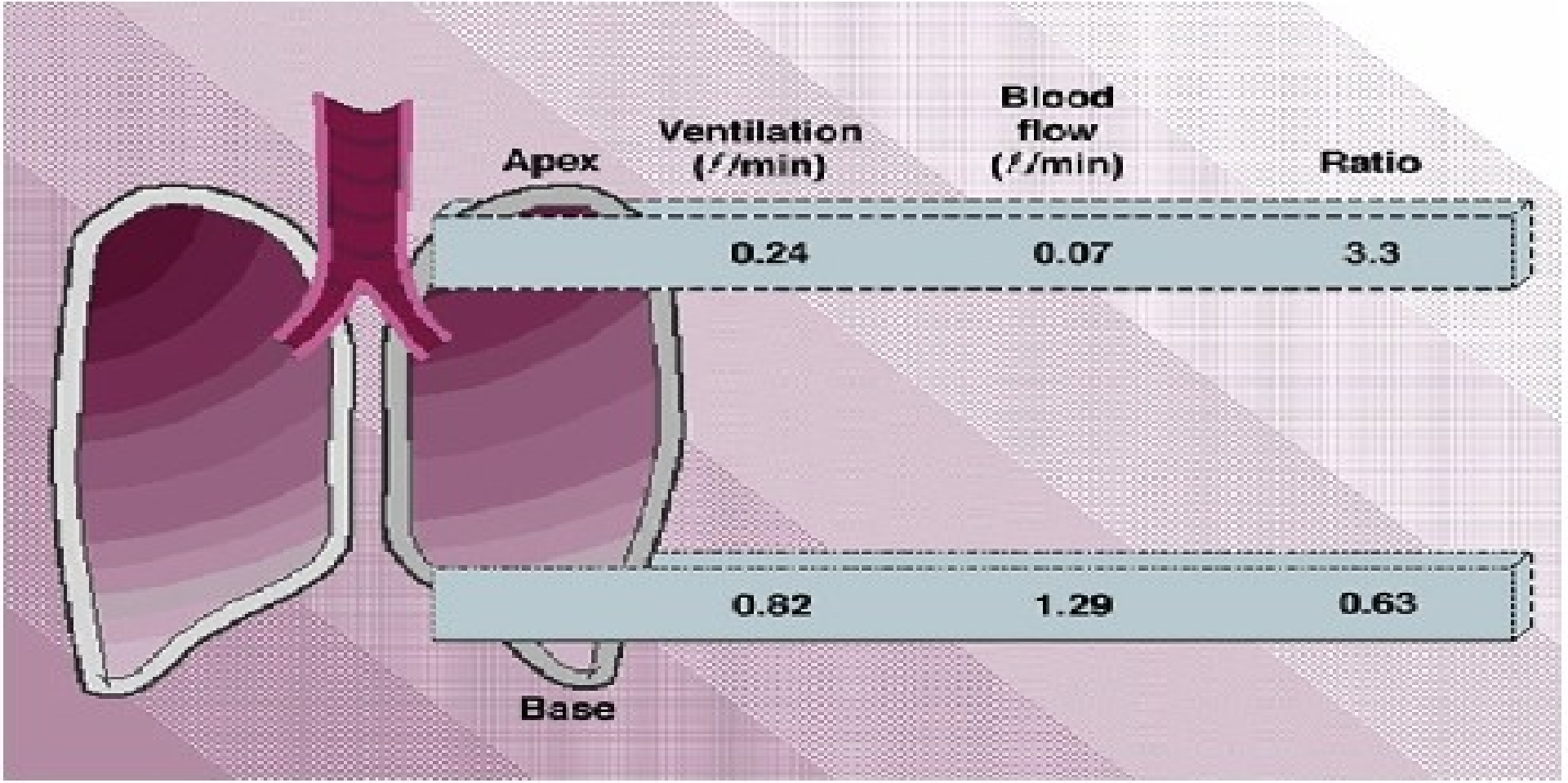
(from base apex of the lung in the upright position)

- **At the apex:**
- **Both V & P are less than at the base.**
- **Ventilation (V) is ↓**
- **Perfusion (Q) is ↓↓↓**
- **So the blood flow is much poor relative to ventilation**
- **V/Q is high = 3.3** **V/ ↓Q so**

3.3

- **At the base:**
- **Both V & P are more than at the apex.**
- **Ventilation (V) is ↑**
- **Perfusion (Q) is ↑↑↑**
- **So the blood flow is much higher relative to ventilation**
- **V/Q is low = 0.6** **V/ ↑Q so ratio**

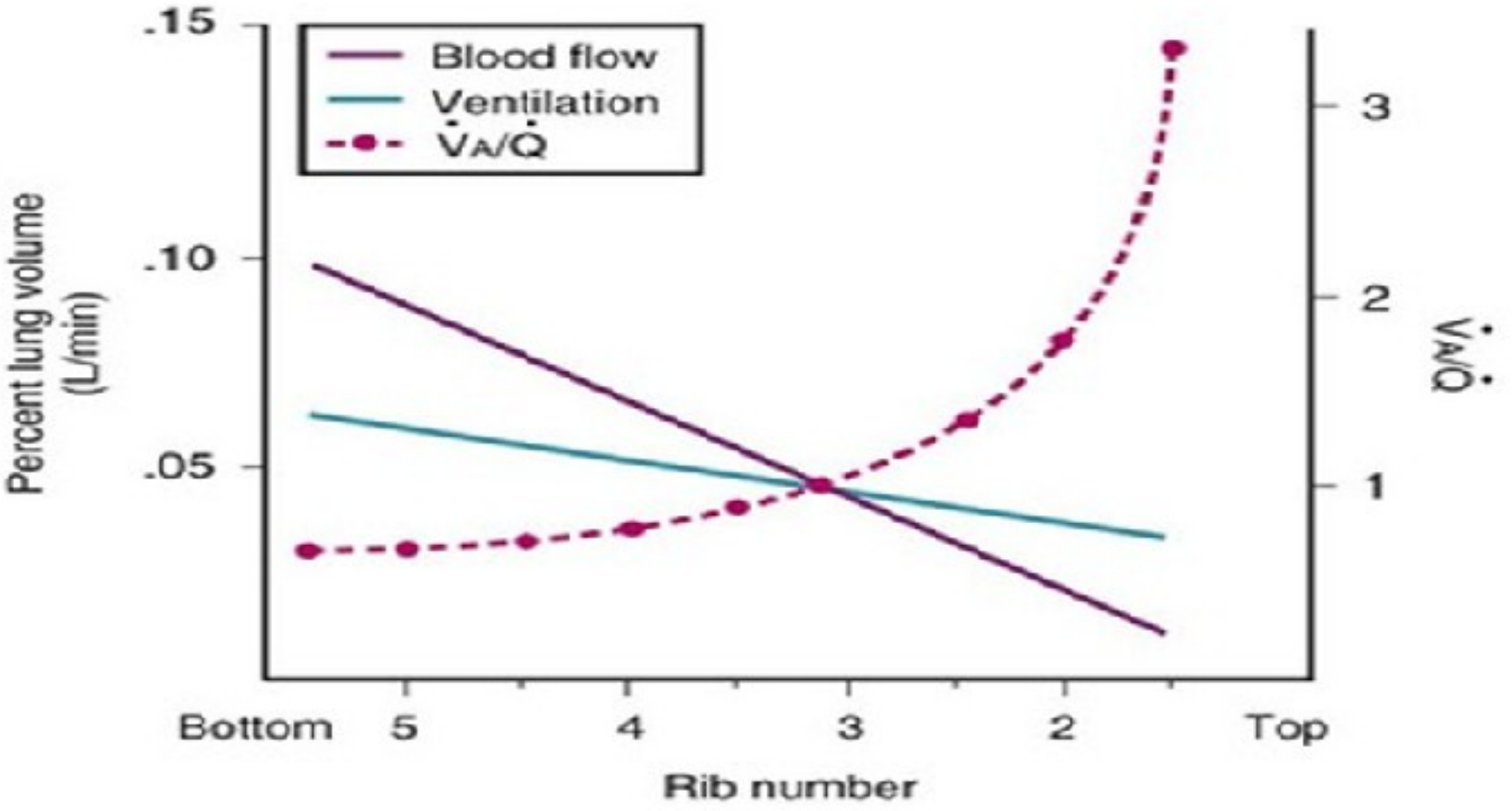
0.6



https://www.slideserve.com

- Therefore, there is a ***normal physiologic mismatching*** of ventilation with perfusion from the base to the apex (0.6- 3.3).

Ventilation perfusion ratio (V/Q)



Pulmonary Physiology,Michael G. Levitzky, 8th edition

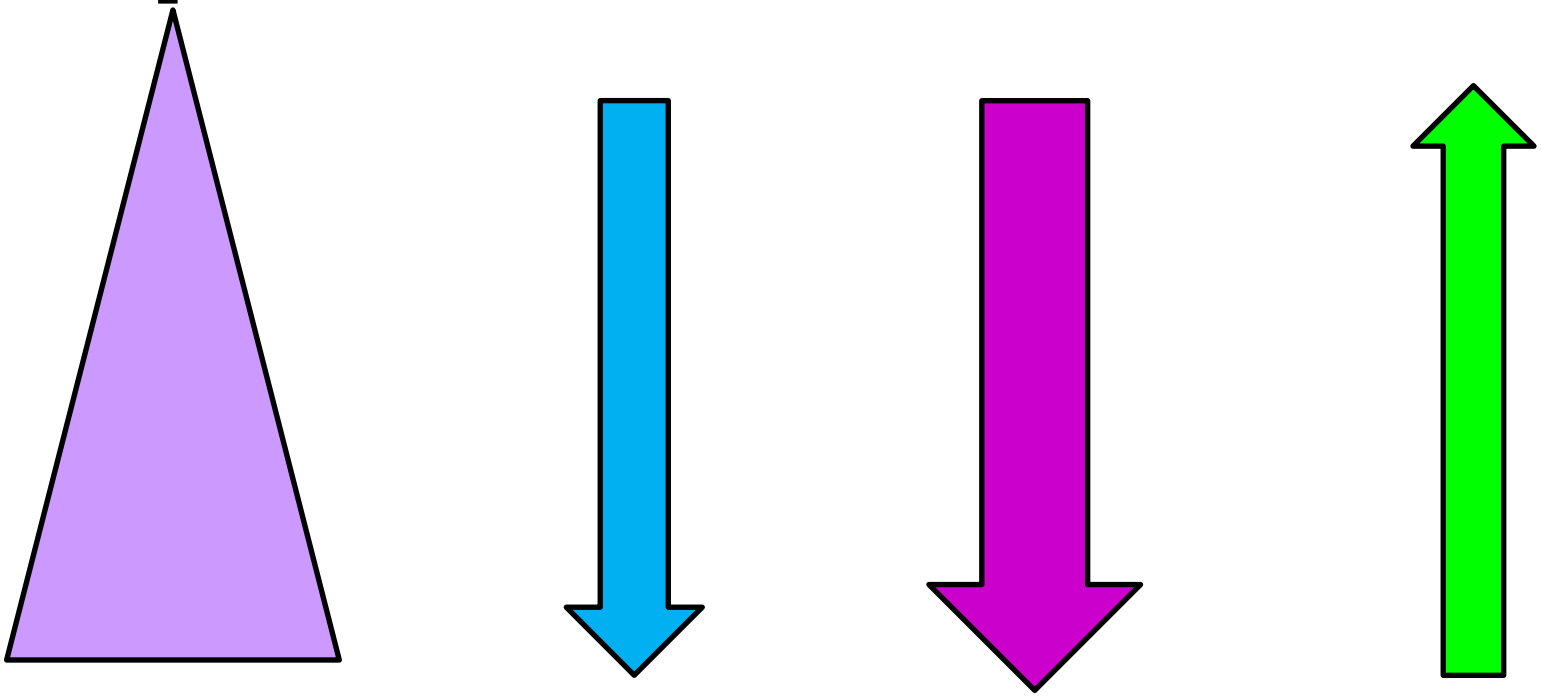
Summary

Apex

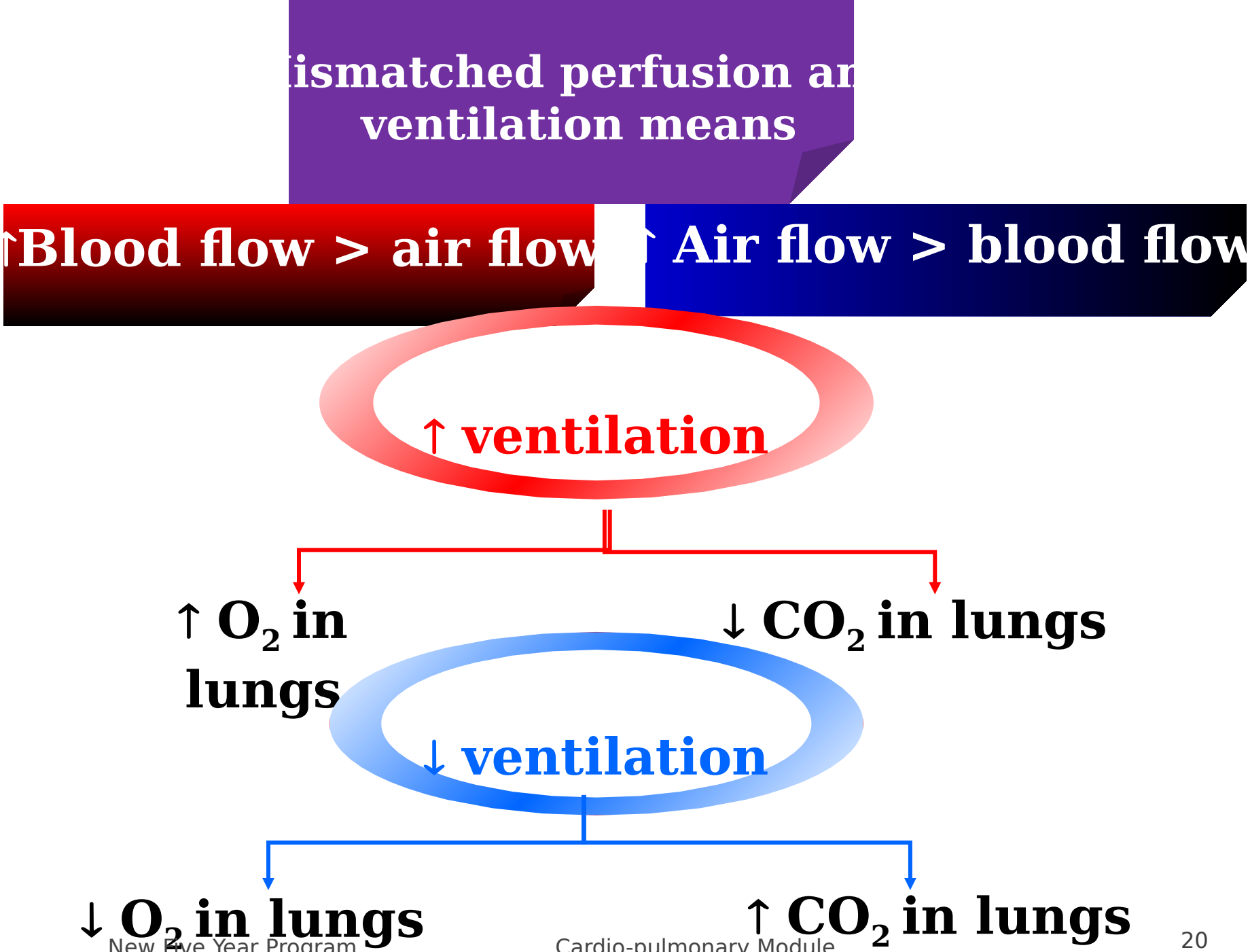
Ventilation

Perfusion

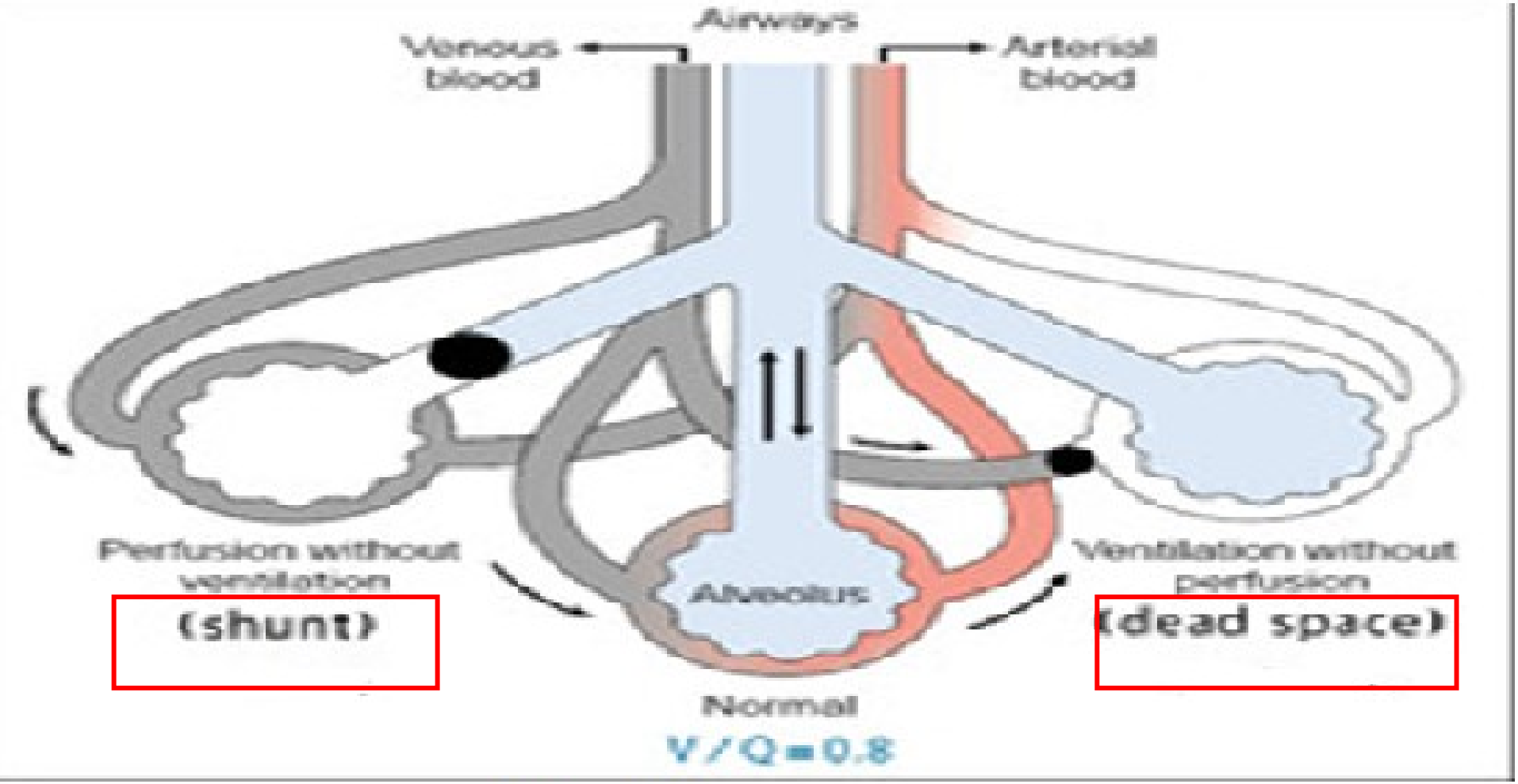
V/Q ratio



Base


lismatched perfusion an
ventilation means
↑Blood flow > air flow
↑ Air flow > blood flow
↑ ventilation
↑ O_2 in lungs
↓ CO_2 in lungs
↓ ventilation
↓ O_2 in lungs
↑ CO_2 in lungs

Ventilation perfusion mismatching

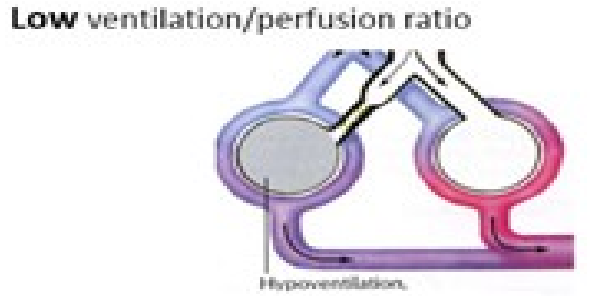


https://www.quora.com

Consequences of low V/Q (↑ Blood flow more than air flow)

↑ Perfusion

↓ Ventilation



Balances airflow	Balances blood flow
↑CO_2 in area	↓ O_2 in area
Relaxation of local airway smooth muscle	Contraction of local pulmonary arteriolar smooth muscle
Dilatation of local airways	Constriction of local blood vessels
↑ Airflow	↓ Blood flow

So if an alveolus is receiving little air relative to its blood flow, local homeostatic mechanisms (V.C by↓ O_2) shunting blood away from the poorly ventilated area.

Consequences of high
(↑Air flow more than blood flow)

Q ↓ Perfusion

↑ Ventilation

Balances airflow

CO_2 in area

Contraction of local airway smooth muscle

Constriction of local airway

↓ Airflow

Balances blood flow

↑ O_2 in area

Relaxation of local pulmonary arteriolar smooth muscle

Dilatation of local blood vessel

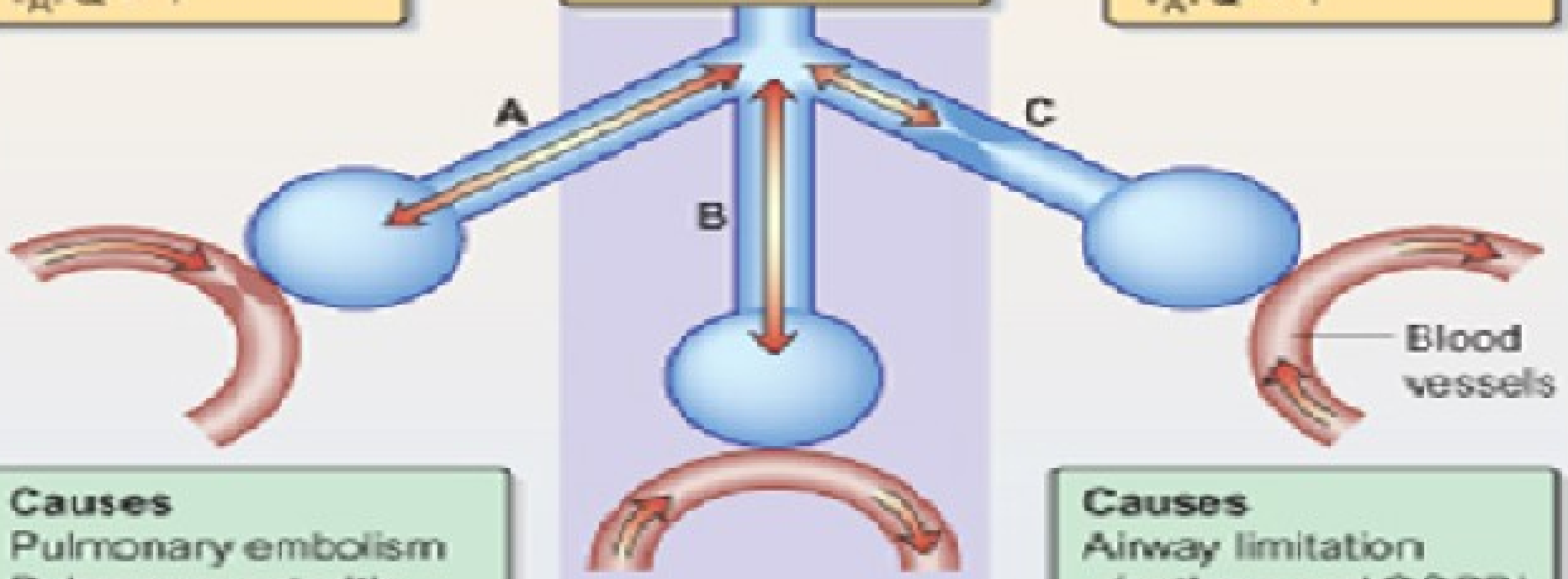
↑ Blood flow

So if an alveolus is receiving excess air relative to its blood flow, these local homeostatic mechanisms (Bronchconstriction) shifting ventilation away from the poorly perfused are

A Physiological deadspace
Ventilation with reduced perfusion
$\dot{V}_A/\dot{Q} > 1$

B Normal
Ventilation and perfusion
$\dot{V}_A/\dot{Q} = 1$

C Physiological shunt
Perfusion with ventilation reduced
$\dot{V}_A/\dot{Q} < 1$



Causes
Pulmonary embolism
Pulmonary arteritis
Necrosis or fibrosis (loss of capillary bed)

Causes
Airway limitation (asthma and COPD)
Lung collapse or consolidation
Loss of elastic tissue (emphysema)
Disease of the chest wall

https://www.icetnepean.org/uploads/5/8/5/1/58510755

Conditions of ventilation/perfusion mismatching (Pathological)

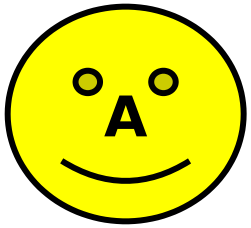
Lung diseases
nphysema, pneumonia & lung colla

Pulmonary embolism

Pulmonary edema

Lecture Quiz

Concerning ventilation perfusion ratio:



a. It falls when an airway is obstructed.

b. It is equal in different lung zones.

c. The apical alveoli are better ventilated than the .basal alveoli

d. It is the difference between the volume of .alveolar ventilation and the pulmonary blood flow

e. It decreases in pulmonary embolism.

SUGGESTED TEXTBOOKS

1. **Ganong's Review of Medical Physiology. 23rd edition , chapter 35, page (599,602,603) & chapter 36 page (620)**
2. **Kaplan Medical USMLE step 1 lecture notes. Section VII, chapter 4 (pages 183-186)**


Thank You